effect. It is a question of the *degree* of condensation and rarefaction. In short, an explosion produces in the air waves of compression and rarefraction which are perceived by the ear as sound, and also can be seen by unequal refraction, if they are sufficiently strong." These phenomena are seen as concentric circles about the point where the explosion occurs; generally, the top of a volcano.—*C. L. M.*

PROPAGATION OF SOUND AND LIGHT IN AN IRREGULAR ATMOSPHERE.

[Reprinted from *Nature*, London, June 13, 1918, p. 284.]

I suppose that most of those who have listened to (single-engined) aeroplanes in flight must have noticed the highly uneven character of the sound, even at moderate distances. It would seem that the changes are to be attributed to atmospheric irregularities affecting the propagation rather than to variable emission. This may require confirmation; but, in any case, a comparison of what is to be expected in the analogous propagation of light and sound has a certain interest.

One point of difference should first be noticed. The velocity of propagation of sound through air varies indeed with temperature, but is independent of pressure (or density), while that of light depends upon pressure as well as upon temperature. In the atmosphere there is a variation of pressure with elevation, but this is scarcely material for our present purpose. And the kind of irregular local variations which can easily occur in temperature are excluded in respect of pressure by the mechanical conditions, at least in the absence of strong winds, not here regarded. The question is thus reduced to refractions consequent upon temperature variations.

The velocity of sound is as the square root of the absolute temperature. Accordingly for 1° C. difference of temperature the refractivity $(\mu-1)$ is 0.00183. In the case of light the corresponding value of $(\mu-1)$ is 0.000294×0.00366, the pressure being atmospheric. The effect of temperature upon sound is thus about 2,000 times greater than upon light. If we suppose the system of temperature differences to be altered in this proportion, the course of rays of light and of sound will be the same.

When we consider mirage, and the twinkling of stars, and of terrestrial lights at no very great distances, we recognize how heterogeneous the atmosphere must often be for the propagation of sound, and we need no longer be surprised at the variations of intensity with which uniformly emitted sounds are received at moderate distances from their source.

It is true, of course, that the question is not exhausted by a consideration of rays, and that we must remember the immense disproportion of wave lengths, greatly affecting all phenomena of diffraction. A twinkling star, as seen with the naked eye, may disappear momentarily, which means that then little or no light from it falls upon the eye. When a telescope is employed the twinkling is very much reduced, showing that the effects are entirely different at points so near together as the parts of an object glass. In the case of sound, such sensitiveness to position is not to be expected, and the reproduction of similar phenomena would require the linear scale of the atmospheric irregularities to be very much enlarged.—*Lord Rayleigh.*

PROPAGATION OF SOUND IN AN IRREGULAR ATMOSPHERE.

By G. W. STEWART.

[Paragraph and synopsis reprinted from *The Physical Review*, vol. 14, No. 4, pp. 376–378. Article is reprinted in *Aeronautics*, Nov. 20, 1919, p. 467.]

Lord Rayleigh's recent reference [1] to and explanation of the "highly uneven character of the sound" from aeroplanes leads the writer to make a record of three additional facts.

Under poor atmospheric conditions, lower frequencies in aeroplane engine sounds become relatively enhanced; under good conditions frequencies of order of 1,000 d. v. are heard at greatest distances. The former is explained by irregularities in the atmosphere and the latter by characteristics of audition.

Intensity of the sound varies much more rapidly than as the inverse square, crude observations giving much more nearly inverse sixth and fourth powers for maximum ranges under fair and good listening conditions, respectively.

SOME UNSOLVED PROBLEMS IN CANADIAN WEATHER.

[Reprinted from Meteorol. Off. Circular, Nov. 1, 1919, pp. 4–5.]

Previous to the meteorological luncheon at the Bournemouth meeting of the British Association for the Advancement of Science, Sir Frederick Stupart read a paper before Section A, on "Some unsolved problems in Canadian weather," making special reference to the climatic peculiarities of the Province of Alberta. He referred to the pressure and temperature conditions of two recent consecutive Januaries in which the mean temperatures at Calgary were 16° F. and 47° F., respectively. During the cold January the mean pressure of the month in the northwest of Canada was as high as 30.75 inches, but in the mild January only 29.97 inches. In the cold January there was intense terrestrial radiation and light northerly winds prevailed, but in the mild January with the low pressure, föhn (chinook) winds persisted, and the temperatuer in Alberta was high continuously. The föhn effect was due to the winds from the Pacific having to traverse four mountain chains so that they were dynamically warmed winds. In the discussion that followed Sir Napier Shaw pointed out certain objections that applied to the conventional explanation of föhn effects.

CLIMATE OF THE BELCHER ISLANDS OF HUDSON BAY.

By ROBERT J. FLAHERTY.

[Excerpt from article on "The Belcher Islands of Hudson Bay" in *Geog. Rev.*, June, 1918, vol. 5, pp. 433–458 (pp. 453–454).]

The climate of the islands differs widely from that of the opposite mainland. Compared with weather reports from Great Whale River for the same period. our observations gave a far greater proportion of overcast skies and fogs, stronger and more constant winds, but higher and more equable temperatures. From October [1915] till early December winds of a velocity up to 50 miles were almost constant, and the sky was continuously overcast.

[1] See this REVIEW, p. 163.

No snow covered the ground permanently until November 15, and no ice was formed in the small lakes near the wintering base until December 4, when the long periods of winds ceased and a fortnight of calm, clear weather set in. The mercury did not fall below zero until January 2—a weather condition without precedent in my experience of the North. Great Whale River early in December had a minimum temperature of $-30°$ and recorded a constant average for the period well below zero [F].

On January 2 [1916] winter commenced in earnest. The month was characterized by constant drifting winds of a maximum force of 70 miles; calm days were unknown; and the average temperature was $-16°$. In February the winds abated; there were many days of sunshine, a few of them almost calm. The average temperature for the month was $-19°$ [F]. Throughout March strong winds again prevailed; by the end of the month the snowfall for the winter had reached its maximum, 4 feet; the average temperature for the month rose to $-9°$. In April and May there was the usual prevalence of wind, and several blizzards occurred, each covering a period of from one to two days. In the latter part of May the weather broke and became warm and summery; in fact, there were heavy thunderstorms at this time. On May 28 sledging over the ice fields was at an end, and by June 10 the field ice surrounding the islands had blown off to southward. Then commenced the most trying time of the year; for hardly two days together did fair weather obtain. From mid-June onward to the time of our departure on September 13 exceedingly heavy gales of wind of from one to three days' duration occurred in every week. The prevailing direction of the winds was south-southwest for not only that period but for the entire year. Days of sunshine were rare; the sky was generally overcast; and rains, accompanied usually by heavy southeast winds, were frequent. According to the natives the weather we experienced during that year was not at all typical; usually, they said, the winds were fewer and less violent, and the temperature during the winter was lower. The remarkable lateness of the freeze-up (December 23) was, they said, without precedent. The minimum temperature for the winter was $-48°$ as compared with the lowest mean reported temperature on the mainland of $-55°$. The maximum thickness of fresh-water ice was $5\frac{1}{2}$ feet, and of sea ice, 5 feet. The maximum temperature for the summer, occurring on July 25 at noon, was 70°.

CLIMATE OF THE GALAPAGOS ISLANDS.

By G. M. McBRIDE.

[Excerpts from article on "The Galapagos Islands" in *Geogr. Rev.*, September, 1918, vol. 6, pp. 229-239 (pp. 236, 237, 239).]

The Galapagos Islands lie at the meeting place of two ocean currents. * * * The Humboldt Current, during nine months of the year when the trades are blowing constantly, divides into two branches off the coast of Ecuador, and larger one veering westward toward the Galapagos. Its velocity is very great, sometimes as much as 75 miles a day. * * * From the northeast a warm current that has come down along the coast of Central America enters this same region. The meeting of the different streams produces what has been called "current doldrums," the current turning east or west, north or south, according to the direction of the wind. The fact that the current from the southeast is cold and that it flows along a desert coast where few streams enter the sea, while the northern current has a higher temperature and bathes a shore whose numerous torrents in the rainy season come laden with sediment, probably accounts for the greater resemblance of fauna and flora to those of Central America.

The climate of the Galapagos is far from equatorial. The presence of cold water from the Humboldt Current reduces still farther the mild temperature to be expected in an oceanic climate. Darwin reported a temperature of 60° F. 1 foot below the surface on the southeast side of Albermarle, and Wolf records surface temperatures of 70° F. and 73° F. at several points between the islands. So marked is the effect of the cold current that, while the geographical equator passes directly through the group of islands the thermal equator lies some distance north, throughout many months departing over 20° of latitude from the geographical line.

This favors the development of strong southeast trades at the islands during most of the year. A further contributing influence to the cool temperature of the ocean in this region is probably found in the upwelling of cold water from the ocean depths.[1] These factors combine to make the Galapagos cooler than any other equatorial land at so near sea level. Even on the lowlands the heat is modified, but the effect of air currents from off a cool water surface is most striking as one ascends the slopes toward the interior.

The zones of vegetation find their explanation in the varying meteorological conditions that exist at different levels. Both in temperature and moisture is this difference notable. Though continuous records are lacking, the observations made by scientists at different seasons of the year give a fairly accurate idea of the climate. While near sea level the temperature often rises to 90° F. (even higher in places sheltered from the wind), Wolf found a fall of one or two degrees for every hundred meters of ascent. Upon the middle slopes some 400 to 600 feet above the sea the average temperature was less than 70° F. On the summit of the hill of San Joaquin in Chatham Island at an elevation given as 2,330 feet, he recorded a mid-day temperature of 57.2° F. during heavy mist and a strong southeast wind. There is little variation from day to day and no marked seasonal difference A passing cloud, or the presence of a fog, produces greater change of temperature than do the seasons, while the greatest range occurs from day to night. After sundown it becomes actually cold on the higher hills, and travelers who pass the nights there in the open air huddle about their camp fires even during the milder months of the year.

The northern islands lie more within the influence of the warmer ocean waters from the Gulf of Panama, those toward the south receiving the full effect of the cold Humboldt Current. The low temperature of the ocean waters had made possible the occurrence of some forms of life rarely found outside the higher latitudes. Several kinds of seals are common, among them *Otaria australis*, found also on the coast of Peru and Chile and about the islands of Tierra del Fuego. Penguins, whose range is generally restricted to the coast of subpolar regions, are here found directly upon the equator; and the great albatross so common about Cape Horn has followed the cold current toward the north, nesting by hundreds upon the island of Hood.

[1] Cf. R. E. Coker: Ocean Temperature off the coast of Peru, *Geogr. Review*, vol. 5, 1918, pp. 127-135.